

**POPULATION STRUCTURE OF *ALOSA MACEDONICA* (VINC., 1921)
(PISCES : CLUPEIDAE) IN LAKE VOLVI (MACEDONIA, GREECE)**

by

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ABSTRACT. — Investigation of the sex ratio in the endemic population of the shad *Alosa macedonica* in Lake Volvi indicated that females predominate (62-97 %) except in May and June coinciding with the high participation of the oldest age-classes of the females. Examination of the age structure showed that age-class III is dominant. Individuals of 181-230 mm total length formed the main bulk of the samples (60 %), the remainder being 111 to 180 mm (37 %) and 231 to 250 mm (3 %) (only one individual 331 mm).

RÉSUMÉ. — L'auteur examine la structure de la population endémique de l'espèce *Alosa macedonica* du lac Volvi. L'étude du sex-ratio de l'espèce a montré qu'au cours du cycle annuel, les femelles dominent (62-97 %), sauf en mai et juin. La classe d'âge III est dominante dans la population. Les individus de longueur totale 181-230 mm forment la majorité du volume des échantillonnages (60 %). Les spécimens dont la longueur totale est comprise entre 111 et 180 mm ne représentent que 37 % et les plus grands spécimens (231 à 250 mm) seulement 3 %.

Keywords : Pisces, Clupeidae, *Alosa macedonica*, sex ratio, age composition, length composition, Greece.

The Macedonian shad *Alosa macedonica* (Vinciguerra, 1921) is an endemic species living holobiotically in the lake Volvi. Only one paper refers to the biology of this species (Sinis & Economidis, in press). The other previous papers were concerned with the systematics of the species (Panagiotopoulos, 1916 ; Vinciguerra, 1921 ; Economidis, 1974 ; Economidis & Sinis, 1982). The present paper described the sex ratio and the age and length composition of this population.

MATERIALS AND METHODS

Sampling was carried out by professional fishermen using a combination of small and large mesh nets (14-50 mm). During monthly sampling, the nets used were 500-1000 m long, turned up at their edges or put in a zig-zag fashion, parallel and at a distance of about 100 m to each other. The nets were set in the afternoon and lifted the next morning. During the June 1978 single sampling, fixed nets were placed close to the shore, where the Macedonian shad move just before spawning. These spawning sites attracted large numbers of fish.

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All samples were brought to the laboratory covered with ice and were examined fresh. Total length was measured from the tip of the snout, with the mouth closed, to the end of the lower lobe of the caudal fin, stretched to its natural position. Sex determination was made macroscopically or microscopically by examination of the gonads. About 20 scales were removed from each individual, of which 5-6 were used for age determination. Scales were cleaned with 8 % NaOH solution (Mann, 1973) and examined under a projection microscope (Visopan, Reichert).

Scales without circuli beyond the last annual check are 1, 2, 3,... year old individuals, whereas those with circulae are 1+, 2+, 3+,... years old. The age-classes I, II, III,... comprise all individuals whatever their exact age, i.e. 1, 2, 3,... or 1+, 2+, 3+,...

RESULTS

An assessment of population structure of the Macedonian shad in Lake Volvi was based on 543 individuals collected at monthly intervals during twelve consecutive months (from 30 September 1977 to 31 August 1978) and 335 individuals collected through a single sampling on 5 June 1978. The population structure was studied by examining : 1) sex ratio, 2) age composition, 3) length, 4) length-age relation.

Sex ratio

Sex ratio examination of monthly samples showed : a) a preponderance of males in the June sample, with a ratio of 1 : 0.32 or 76 % males and 24 % females. b) a slight preponderance of males in the May sample, with a ratio of 1 : 0.92 or

Table I. — Absolute and percent sex ratio per month.

Month	No. of fishes		Ratio M : F	Ratio M : F (%)
	Males	Females		
September 1977	4	36	1 : 9	10 : 90
October -	2	38	1 : 19	5 : 95
November -	1	39	1 : 39	3 : 97
December -	4	36	1 : 9	10 : 90
January 1978	1	37	1 : 37	3 : 97
February -	2	36	1 : 18	5 : 95
March -	3	12	1 : 4	20 : 80
April -	2	40	1 : 20	5 : 95
May -	66	61	1 : 0.92	52 : 48
June -	41	13	1 : 0.32	76 : 24
July -	14	26	1 : 1.86	35 : 65
August -	11	18	1 : 1.64	38 : 62
Total	151	392	1 : 2.64	28 : 72

52 % males and 48 % females. c) an overall preponderance of females to males in all samples in the remaining months, with ratios of 1 : 1.64 to 1 : 1.39. d) higher ratios of females occur from September to April and lower from May to August (Table I).

The overall ratio in the sample of June 1978 was 123 males to 212 females. This corresponds to a sex ratio of 1 : 1.72 or 37 % males and 63 % females. Examination of the sex ratios according to age, revealed the following : a) in the ages 1+ and 2+ there was an insignificant preponderance of males, with ratios of 1 : 0.88 and 1 : 0.98 respectively. b) in the age 3+ there is a significant dominance of females over males, with a ratio of 1 : 2.06 or 33 % males and 67 % females. c) in the age 4+ there is a significant preponderance of females over males, with a ratio of 1 : 11.25 or 8 % males and 92 % females (Table II).

Table II. — Absolute and percent sex ratio per age (sample of 5.6.1978).

Age	No. of fishes		Ratio M : F	Ratio M : F (%)
	Males	Females		
1 +	25	22	1 : 0.88	53 : 47
2 +	45	44	1 : 0.98	51 : 49
3 +	49	101	1 : 2.06	33 : 67
4 +	4	45	1 : 11.25	8 : 92
Total	123	212	1 : 1.72	37 : 63

Population structure according to age-classes

Study of the population structure according to age-classes in the monthly samples showed that : a) age-class 0 was absent in the samples of all months, b) individuals of age-class III constitute the most numerous group from May to August, having already started to increase in numbers during March and April, c) individuals of age-class IV constituted the most numerous group from September to April, having already started to increase in numbers from May to August, d) age-class V is clearly present only from September to February, e) the least represented age-class (after age-class X, in which only one individual was found) is VI (Fig. 1).

Examination of the sample of the 5 June 1978 revealed the following population structure : a) age 3+ (year-class 1975) dominated in both sexes, with a percentage of 40 % for males and 48 % for females, b) age 2+ (year-class 1976) was, after 3+, the most important among males, whilst age 4+ (year-class 1974) among females (Fig. 2).

Population structure according to length

Examination of the population according to total length classes in monthly samples showed that individuals 201-230 mm long constituted the main bulk of the samples from September to February, with the following percentages : 77.5 % in September, 80 % in October, 72.5 % in November, 67.5 % in December, 77.5 %

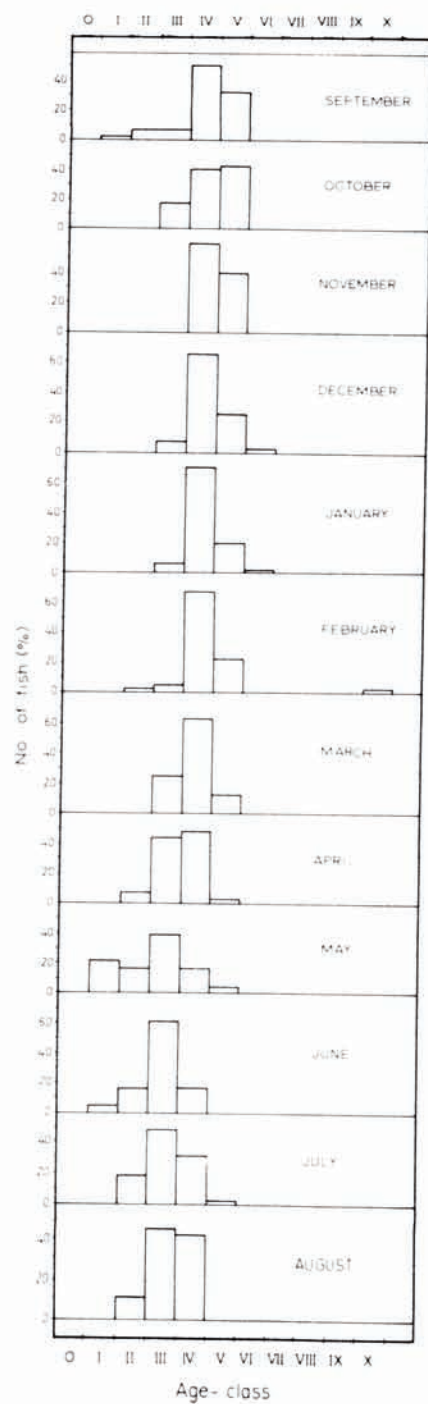


Fig. 1. – Frequency distributions of the age-classes of monthly samples (from September 1977 to August 1978) for both sexes combined.

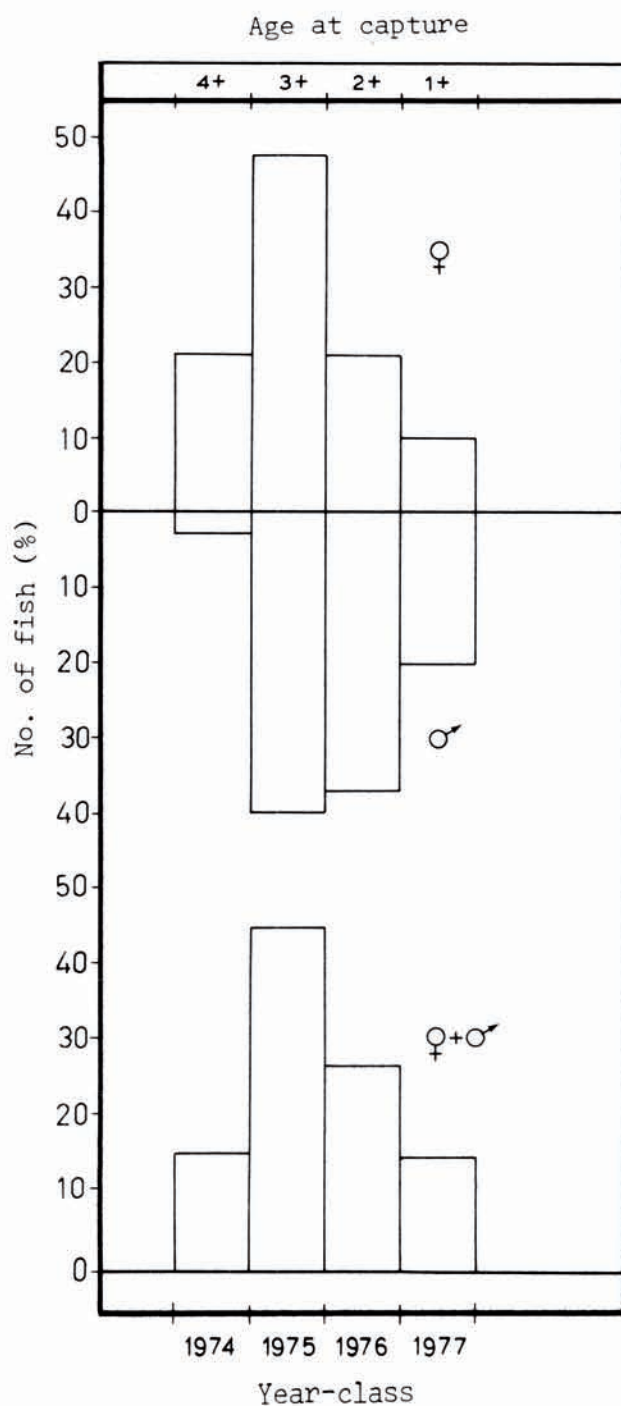


Fig. 2. – Frequency distributions of the year-class for both sex separately and for sexes combined (sample of 5.6.1978).

in January and 60 % in February. During March and April smallest individuals were 191-210 mm (50 %) and 181-190 mm (33.4 %) respectively. In May 30.4 % of the individuals were 121-140 mm long, whereas the greatest percentage included a wide length range over 141 mm. Individuals 151-170 mm long constituted the main bulk of June samples, with a percentage of 55.5 %. In July 35.9 % of individuals were 171-180 mm in length, whilst the greatest percentage included a wide range of smaller or greater lengths. The smallest individuals with a length of 111-120 mm occurred in May, with a percentage of only 4.4 %. Individuals with lengths 231-250 mm were few and represented small percentages mainly from September to January. Individuals exceeding 251 mm length were absent from all samples, with the exception of February, in which a single individual 331 mm long was found (Fig. 3).

The population structure for length classes in the sample of 5 June 1978 is given for each sex separately in Table III. These data revealed that : a) among females the largest number of individuals (percentage of 55.6 %) were found within lengths 151-170 mm ; b) among males the majority of individuals belonged to two length groups, 111-140 mm (48.8 %) and 151-170 mm (39 % ; c) in the sampled population (sexes combined) almost half the total number of individuals (49.5 %) were 151-170 mm in length, whilst the remaining individuals covered wide range of lengths (101-150 mm to 171-200 mm, with one individual of 224,6 mm).

Length composition according to age

Out of the 335 individuals of the sample of 5 June 1978, 123 were males and 212 females, of which 25 of the 123 males were of age 1+ 45 of age 2+, 49 of age 3+ and 4 of age 4+. Table III shows the number of males and females of each age according to the total length classes. Over 95 % of the males of age 1+ were 101-140 mm long ; at age 2+ they were 111-160 mm, at age 3+ they were 131-170 mm and at age 4+ they were 151-180 mm. These figures and table IV show clearly that there is an overlapping between various lengths at successive ages.

Out of the 212 females, 22 belonged to the age 1+, 44 to the age 2+, 101 to the age 3+ and 45 to the age 4+. Over 95 % of the females of the age 1+ were 111-140 mm long ; at age 2+ they were 121-170 mm, at age 3+ they were 141-180 mm and at age 4+ they were 151-190 mm. The above shows that there is also an overlapping between lengths at successive ages.

DISCUSSION AND CONCLUSIONS

The sex ratio varied considerably among the monthly samples as well as in the single sampling. The greatest discrepancies in sex ratios occurred from September to April, coinciding with a high percentage of older age-classes, ranging from 40 % to 70 % in the age-class IV, between 12.5 % and 42.5 % in the age-class V and with a small presence of age-class VI (Fig. 1). Conversely the smallest discrepancies in sex ratios occurred from May to August, coinciding with a high percentage of younger age-classes, ranging from 39 % to 61 % in age-class III, with the clear pre-

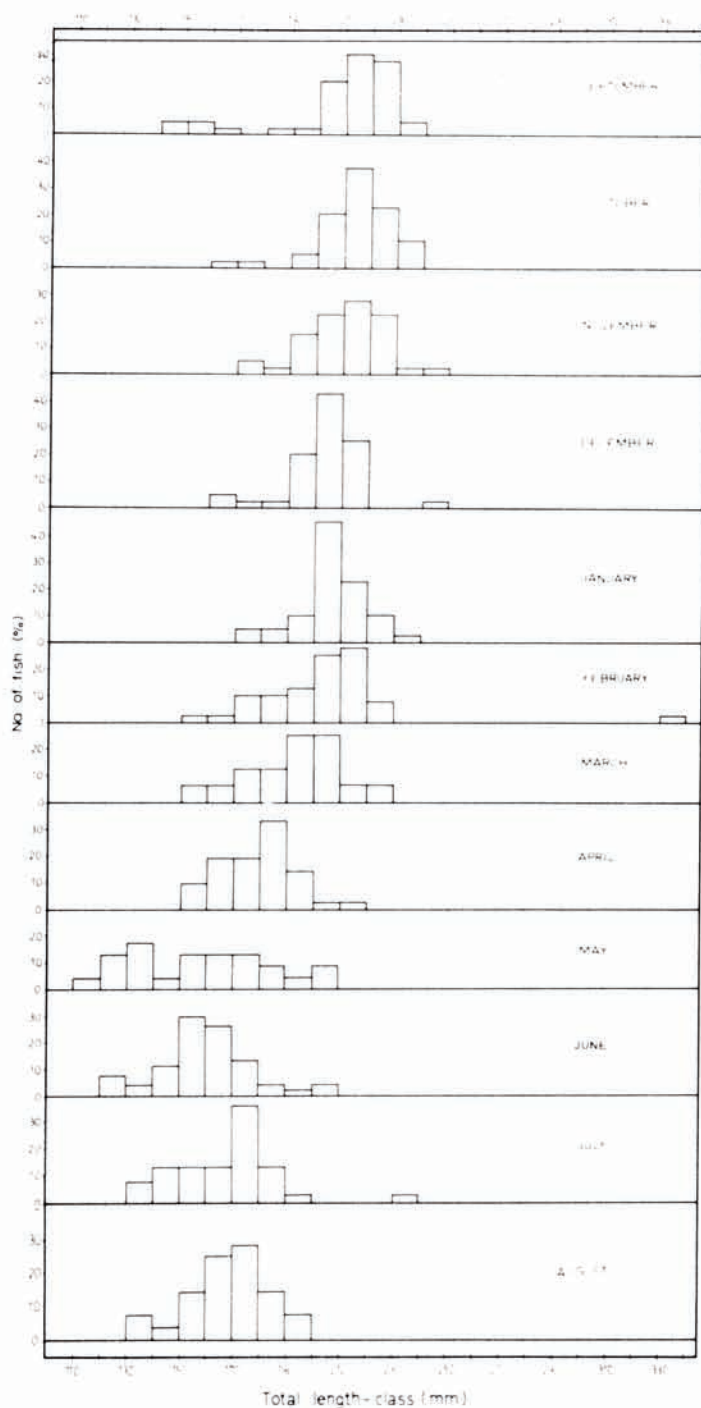


Fig. 3. — Frequency distribution of the total length-classes of monthly samples (from September 1977 to August 1978) for both sexes combined.

Table III. — Frequency distributions of ages and total length-classes per sex (sample of 5.6.1978)

Total length class (mm)	Number of individuals per age and sex											
	1 +		2 +		3 +		4 +		Total			
	F	M	F	M	F	M	F	M	F	M	M+F	
101 - 110	—	2	—	—	—	—	—	—	—	2	2	
111 - 120	3	11	1	7	—	—	—	—	4	18	22	
121 - 130	14	9	15	17	—	—	—	—	29	26	55	
131 - 140	4	3	15	10	1	3	—	—	20	16	36	
141 - 150	—	—	3	5	6	6	1	—	10	11	21	
151 - 160	1	—	5	6	48	27	4	1	58	34	92	
161 - 170	—	—	5	—	35	12	20	2	60	14	74	
171 - 180	—	—	—	—	9	1	15	1	24	2	26	
181 - 190	—	—	—	—	1	—	4	—	5	—	5	
191 - 200	—	—	—	—	1	—	—	—	1	—	1	
201 - 210	—	—	—	—	—	—	—	—	—	—	—	
211 - 220	—	—	—	—	—	—	—	—	—	—	—	
221 - 230	—	—	—	—	—	—	1	—	1	—	1	
Total	22	25	44	45	101	49	45	4	212	123	335	
%	10.4	20.3	20.8	36.6	47.6	39.8	21.2	3.3				
Total M + F	47		89		150		49					
%	14.0		26.6		44.8		14.6					
Mean total length	127.9	121.5	139.4	132.4	161.1	155.9	170.7	163.4				
Mean total length M + F	124.7		135.9		158.5		167.0					

Table IV. — Total length-classes per age for over 95 % of the individuals and overlapping of successive ages.

Total length class (mm)	Number of fishes per age				Overlapping			
	1+	2+	3+	4+	1+, 2+	2+, 3+	3+, 4+	2+, 3+, 4+
Males								
101-110	2							
111-120	11	7			111-140			
121-130	9	17						
131-140	3	10	3			131-160		
141-150		5	6					
151-160		6	27	1			151-170	151-160
161-170			12	2				
171-180			1	1				
Total	25	45	49	4				
Females								
111-120	3	1						
121-130	14	15			121-140			
131-140	4	15	1					
141-150	—	3	6	1		141-170		
151-160	1	5	48	4			151-180	151-170
161-170		5	35	20				
171-180			9	15				
181-190			1	4				
191-200			1	—				
201-210				—				
211-220				—				
221-230				1				
Total	22	44	101	45				

sence of age-class II. The high numbers of young age-classes in the sample of May was due to the use of small mesh fishing nets (14-16 mm), which captured small individuals, even of age-class I. Generally the occurrence of young fishes in the samples taken after May was due to fast-growing young individuals reaching fishable sizes. We consider the slight preponderance of males to females in May (percentage ratio of 52:48) as normal. According to Hellawell (1971) a discrepancy of 5 % in the sex ratio is insignificant. From the above it can be concluded that the preponderance of females is related to the participation of old age-classes in the population. The great preponderance of females among the oldest age-classes is clear in the sample of the 5 June, which was quite large; the sex ratio was examined according to age-classes. Thus, although among age-classes I and II the ratio is normal,

if we consider a difference of 6 % as insignificant in the ratio of age-class I, then in age-classes III and IV the discrepancy in the sex-ratio is considerable, with a dominance of the females. According to Nikolsky (1963) most of the males of fish species die after spawning and this high mortality rate has an adaptive function, the survival of large females being more important than the survival of large males for further reproduction. In the case of the Macedonian shad, however, which breeds for the first time at age 1+, if something like happened, one would have a preponderance of females at age 2+. At age 2+, in our large sample however, there is a normal sex ratio of 1:1, whereas the dominance of females appears for the first time at age 3+. This leads us to the following assumption: the higher mortality rate of the males occurs either after the second spawning and not after the first; or a few male individuals begin to reproduce at age 1+, whereas the majority reproduce for the first time at age 2+. However, this was not verified in any of our samples, although it is known to happen in some species relative to the Macedonian shad, e.g. *Alosa kessleri pontica* (Svetovidov, 1952).

Absence of age-class 0 is due to the small size of the individuals of this class compared to the mesh size of the fishing nets used. The hatching of the young fish takes place by the end of August and their size remains relatively small until the beginning of spring, when they enter age-class I.

Longevity of the Macedonian shad is short and individuals older than 5 years are rarely caught. Out of 878 individuals examined, 2 were 6 years old and only one individual 10 years old.

The study of the length in relation to age revealed that fish within the same total length-class may be of different ages. This means that although there is a relation between the total length of the Macedonian shad and its age, this is of limited reliability for the estimation of age.

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